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DESIGN OF STRUCTURE AND PROPERTIES OF COMPOSITE MATERIALS WITH DISCRETE FIBERS

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ANNOTATIONS

The development of products made of composite materials (CM) is associated not only with shaping and heat treatment, but also with the formation of its structure and physical and mechanical characteristics performed at the design stage of the CM. Thus, the creation of parts from CM is a clear example of the embodiment of the trinity of material, design and technology, since the design and manufacturing processes also provide for the provision of the basic properties of the product material. The greatest efficiency of using KM is achieved by solving the problems of reducing metal consumption, eliminating thermal operations (energy consumption), increasing the characteristics of strength, durability and reliability (specific strength), reducing the weight of structures and increasing technological productivity in combination with the flexibility and versatility of the KM method,

INTRODUCTION

Composite materials (composite, English - complex made up of something) are man-made matrix materials containing two or more components, heterophase in structure, homogeneous in macro- and heterogeneous in micro-headquarters, possessing an additive complex of physico-mechanical properties due to the preservation of the individuality of each component forming the composite.

On an industrial scale, composites are produced by methods of powder metallurgy, processing of polymers and oligomers.

The structural elements of the CM are a matrix and reinforcement placed in a continuous medium of the first. By internal architecture (structure) KM is classified into continuously reinforced (nets, fabrics, foils, bundles and thread systems) and discrete (particles, films, short fibers and felts). In addition, the orientation of the reinforcement is divided into randomly oriented and specially oriented (aniso- and isotropic, orthogonally reinforced, etc.).

The scientific basis of KM design is the principle of combination. In turn, it is based on a combination of two principles: a combination of properties and physico-chemical, mechanical compatibility.

The principle of combination implies the addition of the physical properties of the components in an additive way. The second principle gives limits to the possibility of combining components and implies the preservation of all the distinctive features of the KM during its manufacture and operation.

The main mathematical expressions of the principles of combining components in KM are:

a) Dependences of structural ratios of components. For example,

analytical expressions for CM having pores reflecting the relationship between the apparent and true fractions of fibers and matrix, as well as expressions interpreting component state diagrams and diffusion laws;

b) The dependence of the concentration ratios of the components. For example, an expression establishing a connection between the strength and elastic characteristics of a unidirectional KM through a fiber fraction

$$\sigma_{ув' p} = \frac{\sigma_{тв' p}}{K_\sigma}$$

in case of transverse stretching of the material:
Where:

$$K\sigma = \frac{1 - V_f(1 - \frac{E_m}{E_f})}{1 - (4\frac{V_f}{\Pi})^{0,5} - \frac{E_m}{E_f}}$$

where 'p is related to the tensile stress; Vf is the proportion of fiber; Em and Ef are the Young modules of the matrix and fiber; - the strength of the non-reinforced matrix material under tension;

c) The dependences of the physicomechanical ratios of the materials of the components. For example, the rule for selecting the fiber material according to the known Matrix material: □ud.matr.< □ud.fiber, where □ud.matr and □specific fiber - specific strengths of the matrix and fiber;

d) Dependencies reflecting the technological processes of creating composites and influencing their design.

The stage preceding the numerical design and selection of KM components is a review of scientific and technical literature, which is performed as an analysis of known material in the field of KM. At the same time, the data from literary, reference sources and technical specifications are translated into a magmatic description (mathematical model) reflecting the change and structure of the totality of parameters used in the description in time, the temperature field and the medium.

The design of the KM is carried out according to the criteria (limitations) obtained when creating the aggregate characteristics of the working conditions of the product. Firstly, according to ready-made drawings and design documentation for a technical object (car, airplane, sea transport, etc.), the type of a specific part is determined by evaluating its shape, for example: SHELL (sheet, cylinder, profile); BODY OF ROTATION (gear, shaft, cam); BEAM (rod, panel, monolith), and set the purpose of the part. Secondly, they determine the dimensions of the product and the degree of development of the shape (the number of transitions, mating surfaces and their appearance). At this stage, a preliminary examination and appointment of a method and technology for obtaining a composite product takes place. Thirdly, they establish the scheme of the main stresses and the nature and type of mechanical loading (cyclic, static, dynamic, bending, torsion); they find the critical (dangerous) cross section and the stress tensor. Fourth, they establish the operating conditions (temperature, environment, requirements for the surface of the product - factors of erosion and corrosion, light resistance, friction). At each stage, the data obtained are mathematically formalized, which leads to the creation of a general mathematical model of the composite. At the beginning of KM design, the mechanical properties of the material are assumed to be isotropic.

KM design is limited by design and technological capabilities. Design capability is understood as the ability of a given part shape, structure and combination of selected components to meet product requirements (TK). Technological capability is understood as the availability of equipment and technology that allows you to obtain the designed material. All this is reflected in the design of new composites.

example

Given: uniaxial stretching of a rod with mass m = 0.1 kg, length L = 0.45 m, cross section S = 10-4 m2, force N = 80 kN, at a temperature of 570 K. Let 's determine the calculated density of the projected KM by the formula:

$$\gamma^{\max} = \frac{m}{V} = \frac{m}{SL} = \frac{0.1}{0,4510^{-4}} = 2222 кг/м^3$$

We determine the lower value of the calculated density of the projected KM for porosity 9%:

$$\gamma^{\min} = \gamma^{\max} - \frac{\gamma^{\max}}{100\%} 9\% = 2022 кг/м^3$$

Let's determine the calculated tensile stress in the rod:

$$[\sigma^p] = \frac{N}{S} = \frac{80000}{10^{-4}} = 8 \bullet 10^8 \frac{Н}{м^2} = 800 МПа$$

Let's determine the upper and lower values of the specific strength of the projected KM:

$$\sigma_{уд}^{\min} = \frac{\sigma^p}{\gamma^{\max}} = \frac{800}{2222} = 0,360 МДж/кг$$

$$\sigma_{уд}^{\max} = \frac{\sigma^p}{\gamma^{\min}} = \frac{800}{2022} = 0,396 МДж/кг$$

Thus, the density of the projected KM should be in the range from 2022 to 2222 kg/m3, and the specific strength should be in the range from 0.360 to 0.396 MJ/kg.

Under the pressure of technical and economic reasons, the main of which is the expansion of the raw material base of mechanical engineering, new materials are designed, mostly KM. KM design is carried out by sequential execution of the following stages.

The first stage of KM design at the beginning of its implementation implies an approximate choice of a method for obtaining a composite without specifying technological parameters. First of all, the method of forming the composite is tentatively chosen. It is easy to determine, since each method is limited in its capabilities by the shape, size, accuracy (tolerances) and quality of the resulting surface. In addition, the current technological criterion narrows the area of choice of composite components, especially the matrix, according to plastic properties. The temperature interval of shaping is assigned. Since each type of shaping has its own specific anisotropy of properties, for example, fiber orientation, the composite structure is selected. For all variants of the task, the method of forming the rod is hot extrusion. The energy cost of extrusion of KM with a metal matrix is 1.5 • 1.7 times greater than that of KM with a polymer matrix and is 2 MJ/kg.

SELECTION OF MATRIX MATERIAL KM

Here, the design requirements create constraints that are considered in sequence;

- Restrictions on the density of the product (weight of the structure);
- Limitations on specific strength and elastic characteristics;
- Limitations on strength, rigidity and durability;
- Restrictions on the surface properties of the product;
- Restrictions on the time of operation of the product;
- Restrictions on the operating temperature of the product;
- Cost restrictions.

The matrix material and alternative options are calculated, the first specification of the method of obtaining the product and an approximate economic calculation are carried out. Choose the most acceptable options for the matrix material and technologies. Currently, materials scientists and designers of KM use computer reference information systems and the INTERNET when searching for materials. In this paper, the data given in the reference tables are used. The search algorithm given above can be supplemented with other restrictions. During the selection of the matrix material , two cases are possible:

1. Known materials without reinforcement do not meet the design criteria. This is where the transition to composite takes place;
2. Known materials for matrices meet the requirements of both structural and technological capabilities. In this case, the design of KM is not interrupted, but options for less durable ones are being considered (rigid) and cheaper matrix materials. For example, if a matrix of plastic mass was selected, then it becomes possible to introduce fillers (chalk, paper waste, etc.), which has a positive effect on the cost of the product. The use of cheap reinforcing elements (steel wire, glass threads, fibers and fabrics) in a composite analog of a matrix material in this case is a sufficient condition for meeting the requirements for design and technological limitations. Taking into account the above-mentioned existing methods for designing the structure.

Properties of matrix components of composite materials

Material	Density, γ кг/м³	Endurance, $\sigma_в$ MPa	Operating temperature T, °C	Specific energy costs for manufacturing мате-риала, kJ/kg
AD-1	2700	410	660	180
AK-4	2650	430	600	200
AL-1	2750	470	560	210
B-95	2800	600	470	300
PTE-1 (Ti)	4700	1650	500	250
Beryllium	1300	1360	500	240
NP-2 (Ni)	8900	450	1100	540
XN70Y	7800	750	1400	600
Polystyreneoл	950	40	300	160
ED-10	1160	35	370	180
Fenelon	1350	120	400	200
Polyethyleneeн	1050	35	320	220
Fluoroplaster Ф	2150	35	560	120
SP90-3 (Fe-C)	7800	700	400	300

The calculation of specific strength shows that for KKM F + VMN, a restriction on the interval of TS specific strength is performed.

Thus, for the manufacture of the rod, it is necessary to choose a matrix of fluoroplast, carbon fiber reinforcement, with a diameter of 6 microns and a length of 882 microns with a concentration of 0.21.

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E-LEARNING RESOURCES

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2. www.ziyonet.uz
3. www.lex.uz
4. www.bilim.uz
5. http://twirpx.com/
6. http://studbooks.net/
7. http://trove.nla.gov.au/
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